

BREEDING HABITS AND ASSOCIATED PHENOMENA IN SOME INDIAN BATS¹

Part IX — *Hipposideros lankadiva* (Kelaart) — Hipposideridae

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Specimens of *Hipposideros lankadiva* (Kelaart) were collected from old temples and unused tunnels from Chandrapur about 160 kilometres from Nagpur. This large bat lives in colonies which vary from a scattered gathering of 50 to 100 individuals to thousands. The bat is very active and both males and females are found in the same colony throughout the year. It has an annual breeding cycle and each female delivers a single young one during each cycle. Deliveries in the colony occur from the 10th May to the end of May. There is a dominance of the left side of the genitalia over the right a few cases showing ovulation and pregnancy in the right. The gestation period is prolonged due to a retarded development of the embryo after implantation and is of about 260 days. Females are sexually quiescent only for a short period from 1st week of August to the middle of August. The young ones do not attain sexual maturity in the year of birth. The colony shows a female dominant sex-ratio.

INTRODUCTION

Although the family Hipposideridae is represented by several species in India, some aspects of the breeding biology of only a few species have been studied (Gopalakrishna and Moghe 1960; Gopalakrishna and Bhatia 1980; Gopalakrishna and Bhatia 1983).

The present paper on the breeding habits of *Hipposideros lankadiva* is a part of the overall programme of the study of reproductive biology of Indian bats undertaken in this laboratory. This species has been chosen for detailed study because it not only exhibits some unusual features but it also differs considerably from the breeding behaviour of a closely related species, *Hipposideros speoris* (Gopalakrishna and Bhatia 1983) in spite of living in the same geographical situation and under the same ecological conditions. In fact, *Hipposideros lanka-*

diva is often associated with *Hipposideros speoris* since the two species live in the same roost.

MATERIAL AND METHODS

Specimens of *Hipposideros lankadiva* were obtained from their natural roosting places at and near Chandrapur about 160 kilometres south of Nagpur. The specimens were collected from November 1976 to May 1979 such that every calendar month was represented by one collection or more. The specimens were netted at random during daytime and sometimes during the night. After recording the significant characteristics of the external genitalia in the males and the mammary nipples and pubic dugs in the females, the animals were killed by chloroform and their body weight recorded by a sensitive spring balance. The reproductive tracts were dissected out and fixed in Bouin's fixative or 10% formalin and were preserved in 70% alcohol. In the case of the males the right testis of each specimen was taken out of 70%

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BREEDING HABITS IN SOME INDIAN BATS — PART IX

TABLE I
SUMMARY OF THE COLLECTION DIARY

Date of collection	MALES			FEMALES							Total	Grand Total
	Immature Attached	Free	Adult	Immature Attached	Free	Adult Non-pregnant	Pregnant	Lactating	Right horn	Left horn		
	1	2	3	4	5	6	7	8	9	10	11	12
2-1-79	—	—	2	2	—	2	—	—	4	—	6	8
5-1-78	—	—	—	—	—	—	—	—	2	—	2	2
14-1-79	—	1	2	3	—	1	—	—	2	—	3	6
5-2-79	—	—	2	2	—	1	—	—	4	—	5	7
19-2-78	—	1	—	1	—	—	1	—	10	—	11	12
23-2-78	—	1	2	3	—	2	—	1	4	—	7	10
28-2-78	—	—	3	3	—	1	—	1	4	—	6	9
9-3-79	—	—	2	2	—	2	—	1	4	—	7	9
18-3-78	—	—	1	1	—	2	—	2	9	—	13	14
25-3-79	—	—	2	2	—	—	—	—	4	—	4	6
2-4-77	—	—	3	3	—	—	—	—	—	—	—	3
9-4-78	—	—	—	—	—	—	—	—	4	—	4	4
10-4-77	—	1	3	4	—	3	—	2	9	—	14	18
16-4-79	—	—	4	4	—	2	—	—	3	—	5	9
22-4-78	—	—	2	2	—	2	—	1	4	—	7	9
1-5-78	—	—	5	5	—	—	—	—	2	—	2	7
10-5-79	1	—	2	3	—	2	—	—	3	1	6	9
13-5-77	—	—	6	6	—	—	—	—	—	—	—	6
14-5-77	1	—	—	1	—	3	—	1	4	1	9	10
24-5-78	1	1	—	2	2	1	—	—	1	3	7	9
6-6-77	4	1	—	5	1	2	1	—	—	11	15	20
13-6-78	1	—	7	8	—	1	1	—	—	6	8	16
21-6-78	1	—	—	1	—	1	—	—	—	2	3	4
25-6-77	—	2	6	8	—	—	—	—	—	—	—	8
26-6-77	1	3	3	7	—	5	3	—	—	6	14	21
1-7-78	—	1	9	10	—	—	3	—	—	—	3	13
9-7-78	—	1	3	4	—	—	1	—	—	2	3	7
16-7-77	—	—	4	4	—	1	2	—	—	—	3	7
20-7-78	—	1	4	5	—	—	3	—	—	3	6	11
30-7-77	—	1	5	6	—	6	3	—	—	2	11	17
3-8-77	—	—	3	3	—	1	4	—	—	—	5	8
12-8-78	—	2	2	4	—	3	5	—	—	2	10	14
21-8-77	—	2	5	7	—	—	—	—	—	—	—	7
24-8-78	—	—	5	5	—	4	3	—	3	—	10	15
5-9-78	—	—	2	2	—	4	3	1	12	—	20	22
10-9-77	—	3	6	9	—	1	—	—	2	—	3	12
10-9-78	—	—	2	2	—	2	—	—	8	—	10	12
14-9-78	—	—	2	2	—	—	—	—	1	—	1	3

TABLE I (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12
24-9-78	—	1	8	9	—	2	—	1	8	—	11	20
30-9-77	—	—	2	2	—	1	—	—	3	—	4	6
1-10-77	—	—	2	2	—	1	—	1	6	—	8	10
14-10-78	—	—	2	2	—	—	—	—	3	—	3	5
17-10-78	—	—	6	6	—	4	—	—	9	—	13	19
28-10-77	—	—	6	6	—	7	—	3	4	—	14	20
1-11-76	—	3	9	12	—	—	—	—	2	—	2	14
14-11-76	—	—	3	3	—	—	—	—	1	—	1	4
18-11-77	—	—	1	1	—	—	—	—	1	—	1	2
20-11-78	—	—	4	4	—	4	—	—	5	—	9	13
10-12-77	—	—	4	4	—	1	—	1	8	—	10	14
18-12-78	—	—	2	2	—	1	—	1	2	—	4	6

TABLE II

MONTHWISE COLLECTION OF SPECIMENS

Month	Immature attached	males free	Adult males	Total males	Immature Attached	females Free	Adult females	Total females	Grand total
January	—	1	4	5	—	3	8	11	16
February	—	2	7	9	—	4	25	29	38
March	—	—	5	5	—	4	20	24	29
April	—	1	12	13	—	7	23	30	43
May	3	1	13	17	2	6	16	24	41
June	7	6	16	29	1	9	30	40	69
July	—	4	25	29	—	7	19	26	55
August	—	4	15	19	—	8	17	25	44
September	—	4	22	26	—	10	39	49	75
October	—	—	16	16	—	12	26	38	54
November	—	3	17	20	—	4	9	13	33
December	—	—	6	6	—	2	12	14	20
	10	26	158	194	3	76	244	323	517

alcohol, gently rolled on filter paper and quickly weighed in a Mettler balance. This gave accurate relative weights of the testes of different specimens since all the testes of all the males were subjected to the same procedure. Table I gives the summary of the collection diary and Table II gives the monthwise collection of the specimens.

OBSERVATIONS

1. *General remarks*

Hipposideros lankadiva is a large bat as compared to other hipposiderid bats. The maximum weight of the male is 76 gms and that of the non-pregnant female 55 gms. The species shows a variety of fur colour. The

most common types are fulvous brown and reddish brown. Sometimes a greyish brown and bright golden red type of fur is also noticed. A golden colour of the fur is also noticed in some other bats of the family Hipposideridae—*Hipposideros caffer* in Africa and *Hipposideros calcaratus*, *Hipposideros cupidus* and *Hipposideros galeritus* in New Guinea (Brosset 1962, Menzies 1973). In all these cases the change of colour was attributed to high humidity, high temperature and high ammonia concentrations.

Hipposideros lankadiva lives in colonies in old temples and unused tunnels. This bat is very active and flies away on the slightest disturbance. The population in the different colonies varies from a scattered gathering of about 50 to 100 individuals to thousands. Brosset (1962) reported a colony of 5,000 to 7,000 specimens from Mandu, in Central India. In Chandrapur the largest colony was about 2,000 to 3,000 specimens clinging to the crevices in the wall of old temples and tunnels. The regular roosts are full of huge deposits of guano. Specimens of *Hipposideros lankadiva* are found together with *Hipposideros speoris* in some roost. Males and females are collected from the same roost throughout the year indicating that there is no segregation of sexes either on the basis of age or on the basis of sexual activity during any season of the year.

2. Female genitalia

The ovary ovoid in shape and is enclosed in a complete ovarian bursa. It is attached to the dorsal ligament by a narrow hilus. The Fallopian tube arises from the posteromedian aspect of the ovarian bursa, and, after taking a slightly tortuous curve around the cranial surface, bends caudally to open into the cranial end of the respective uterine cornu. The uterus is bicornuate and the two uterine cornua are morphologically symmetrical. Each uterine

cornu of a non-pregnant adult specimen appears to bulge at its anterior end. The two cornua meet mesially forming a V-shaped structure. The uterine cornu measures 5 mm in length. The vagina is about 9 mm long and opens by a transverse slit-like opening.

A pair of pectoral mammary teats are present on the ventrolateral sides of the thorax and a pair of pubic dugs on the ospubis, one on either side of the midline. In the majority of the females, the right pubic teat is longer than the left, suggesting the probability of its being used more.

The young one clings to the ventral side of the mother's abdomen with the pubic dugs in its mouth. Thus the unweaned young one is found attached to the mother in the head to tail position during rest. Most of the young ones hold the right pubic teat and sometimes both in their mouth keeping the hind limbs free or forming a loose embrace around the neck of the mother. While sucking, the young holds the mammary nipples by the jaws, while the claws of the feet are firmly anchored to the pubic teats.

3. Breeding habits

Examination of the collection diary and Tables I and II reveals that *Hipposideros lankadiva* is a seasonally breeding species and exhibits several interesting features. Pregnancy as evidenced by the presence of a bulbous uterine cornu, was noticed from the first week of September to about the last week of May. Microscopic examination of the female reproductive organs revealed that the females collected on the 12th of August had not copulated and both the ovaries contained vesicular follicles only. However, out of the eight adult females collected on 24th August, four had pre-ovulatory follicles in the left ovary and sperms in their genital tracts, three had an early extrovert corpus luteum each in their

left ovary and an egg in the eight cell stage in the Fallopian tube thereby indicating that ovulation and fertilisation must have taken place a day or two earlier and one had multilaminar follicles with intercellular chinks in the left ovary.

Out of the 14 females collected on 5th September, one had an unfertilised egg surrounded by cumulus cells in the ovarian bursa and sperms in the uterine part of the Fallopian tube and uterus, three had pre-ovulatory follicles about to rupture and sperms in the genital tract and the remaining nine showed unquestionable pregnancy in the left uterine cornu. Some females collected on 9th and 10th September showed late stages of cleavage in the Fallopian tube with degenerate sperms in the uterine glands and those on 24th September had free blastocysts in the uterine lumen. Some females collected between 1st to 17th October showed various stages of implantation. From these facts it is evident that all the females in the colony copulate and conceive approximately between the 22nd August and 5th September.

The first delivered baby was collected on 10th May. The uterus of the mother had not involuted and the young one had a small umbilical stub, closed eyelids, was without hair and weighed 8 gms. Since the full term foetuses were of the same weight it is evident that this young bat must have been delivered a few hours earlier. During subsequent collections more and more females in the colony were found to have delivered their young ones. One pregnant female collected on 24th May had a full term foetus which, from its size, weight and development, would have delivered in a day or two. Pregnant females were not present in the colony after this date. The above facts indicate that all deliveries take place within a span of two weeks that is between second and last week of May.

The females carrying a young one at their breasts were collected from 10th May to 26th June. It cannot be ascertained if the young ones were incessantly carried by their mother during this period. The highest weight of the young at breast was 22 gm. The first batch of young were collected on 6th June and weighed 25 gm. Assuming that these young ones had been delivered in the 1st batch (10th May) and that they were carried by their mother till 6th June, it is evident that the mother carries the young for about 26 days. However, even after they leave their mothers they may be sucking the milk of the mother for some time more as evidenced by the fact that the mammary glands of the females continue to ooze milk on pressing till 12th August, and curdled milk was found in the stomach of several free young ones.

From the foregoing account of the breeding habits of *Hipposideros lankadiva*, the annual reproductive cycle of the female can be recognised into the following periods:

1. A short period of sexual quiescence from first week of August to about the middle of August.
2. Oestrus- copulation and fertilisation during the latter half of August and the first week of September.
3. Pregnancy- from about the latter half of August to first week of May.
4. Parturition- during the 10th and the end of May.
5. Lactation- from the second week of May to the first week of August.

4. Duration of pregnancy

The duration of pregnancy as is evidenced by the above data is of about 260 days allowing a margin of 4 to 5 days on either side — the date when the first delivery occurred (10th May) and the date when the egg in early cleavage was noticed (24th August). An inter-

esting feature of the pregnancy of this species is that the uterine bulb did not increase noticeably until the end of December. However, from January onwards the bulbs started increasing in size until parturition in May. These facts suggest that after implantation of the blastocyst the embryonic development is retarded for about four months until December, and is responsible for the unusually prolonged pregnancy of this bat. The factors responsible for this are not known.

5. *Number of young*

Examination of the collection diary reveals that out of 169 pregnant females collected, 152 carried the embryos in the left cornu and 17 in the right. Histological examination of the ovaries of these pregnant specimens revealed that the corpus luteum was invariably present in the ovaries ipsilateral to the uterine cornu carrying the conceptus. Evidently, transuterine migration of the embryo had not taken place in any specimen. Further, there is no evidence to indicate that there is physiological alternation of the two sides of the genitalia. On the other hand there is a distinct unilateral physiological dominance of the left side of the female genitalia. Such a dominance of the left side is reported in other hipposiderid bats (Gopalakrishna and Moghe 1960, Gopalakrishna and Madhavan 1978, Madhavan *et al.* 1979, Gopalakrishna and Bhatia 1983).

6. *Growth and maturity*

It has already been mentioned that all the females deliver within a span of a fortnight (10th May to 24th May). The newly born young ones weigh about 9 gm when they leave the mother. The first batch of free young ones weighing 22 gm were collected on 6th June and young ones at breasts were collected up till 21st June. Milk was present in the mammary glands until 12 August. Examination of the stomach contents of juveniles weighing 25 to 30 gm re-

vealed the presence of curdled milk in their stomach. It is evident that the young ones must be visiting the mother for sucking even after they become free. Evidently the young ones grow rapidly during the period when they suck milk and their body weight increases three times by the time they are weaned. These juveniles can be recognised by their darker fur colour. After 30th July it is not possible to recognise the juveniles from adults on the basis of fur colour and size of the body.

The mammary nipples and pubic dugs are inconspicuous in virgin females, but they increase in size during the first pregnancy and lactation and remain conspicuous throughout the rest of the life of parous females. Thus, the size and nature of the character of the mammary nipples and pubic dugs can be used as valid criteria to determine the sexual maturity or otherwise of the females.

The collection diary reveals that some females having inconspicuous mammary nipples and pubic dugs were present in the colony during the breeding and pregnancy periods. On histological examination they revealed a typical juvenile conditions of the ovaries and genitalia. Amongst the males also a number of immature specimens (immature as revealed by the size and histological characteristics of the testis and accessory sex organs) were collected during the breeding season. The occurrence of immature females and males during the breeding season indicates that sexual maturity is not attained in this species in the year of birth. It has already been noted that the first batch of delivered young were collected on 10th May and that copulation took place on 24th August. These facts indicate that the animals of either sex take at least 16 to 17 months to attain sexual maturity. During the breeding season the female population shows three categories of individuals — i) im-

mature females, ii) nonparous females experiencing their first pregnancy and iii) parous females in their second or subsequent pregnancies.

7. Sex-ratio

Among 517 specimens netted at random at regular intervals for two years there were 323 females and 194 males. Since there is no segregation of sexes with regard to age or season, this should be the natural sex-ratio of this species. The number of sucking individuals in the collection was too small to give any indication about the sex-ratio at birth. But among 102 free immature specimens collected there were 76 females and 26 males (Table II). It is thus evident that there is a preferential mortality of the males during the growth period. This unbalanced sex-ratio during the immature period continues to the adult period giving an unbalanced female dominant sex-ratio in the colony. During the period of copulation and ovulation (last week of August and first week of September) also, the adult population is female dominant.

Amongst the hipposiderid bats a female dominant sex-ratio has been reported in *Hipposideros ater ater* (Gopalakrishna and Madhavan 1978), *Hipposideros fulvus fulvus* (Madhavan *et al.* 1979) and *Hipposideros speoris* (Gopalakrishna and Bhatia 1983). The present observations confirm the female dominant sex-ratio in this species and is at variance with the report by Abdulali (1949) for this species. Perhaps Abdulali (1949) based his conclusions on only a few isolated collections from only one or two colonies. Hence he probably missed the exact sex-ratio of this animal. This bat, therefore, conforms to the norms of sex-ratio noticed by most workers in most of the Indian and European bats in general and hipposiderid bats in particular.

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